

Economic Perspectives on Energy Security and Sustainability: Financial Viability of Renewable Energy Projects, Economic Incentives, Green Finance, and Carbon Pricing**Kumar, Rajesh**

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CITATION

Kumar, R., (2025). Economic Perspectives on Energy Security and Sustainability (Financial Viability of Renewable Energy Projects, Economic Incentives, Green Finance, and Carbon Pricing) *Shodh Manjusha: An International Multidisciplinary Journal*, 02(02), 253–258.
<https://doi.org/10.70388/sm250158>

Article Info

Received: May 21, 2025

Accepted: July 23, 2025

Published: Aug 10, 2025

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<https://doi.org/10.70388/sm250158>

Abstract

As the world's need for energy grows, we must find cleaner and safer ways to produce it. Traditional energy sources like coal and oil pollute the environment and are not sustainable for the long term. This paper looks at how we can use economic strategies to support energy security and sustainability. We will explore how renewable energy can be financially practical, how governments offer incentives for clean energy, the role of green finance, and how carbon pricing can help reduce pollution. Together, these ideas can help us move towards a greener and more secure energy future.

Keywords: sustainability, environment, economics, energy security

Introduction

Energy is essential for daily life and economic development. We need energy to run factories, power homes, fuel vehicles, and support modern lifestyles. But using fossil fuels like coal and oil leads to pollution, climate change, and health problems. At the same time, we must ensure there is always enough energy available—this is known as

energy security.

Energy security means having a steady and reliable supply of energy at affordable prices. Sustainability means producing energy in ways that do not harm the environment or use up

natural resources for future generations. Balancing both is a global challenge. Many countries are now investing in renewable energy sources like solar, wind, hydro (water), and bioenergy to meet these goals.

To make this change possible, we need smart economic tools and decisions. This paper explores how money, investments, and government policies can support clean energy and make our energy system secure and sustainable.

Financial Viability of Renewable Energy Projects

1. Upfront Costs and Technology Improvements

One major challenge for renewable energy is the high initial cost. Building solar parks, wind farms, and hydroelectric plants requires a large amount of money. For example, a 100 MW solar power plant may cost over \$100 million to build. However, once installed, these systems have very low maintenance and operating costs. Technology is improving rapidly. The price of solar panels has fallen by more than 80% since 2010. Wind turbines have become more efficient and can now produce more electricity from lower wind speeds. Battery storage systems, which are important for using solar and wind energy, are also becoming cheaper and better. For instance, lithium-ion battery prices dropped from over \$1,000 per kWh in 2010 to around \$150 per kWh in 2023. These improvements make renewable energy more affordable and attractive to investors.

2. Comparing Costs: LCOE

The Levelized Cost of Electricity (LCOE) is used to compare different types of power generation. It calculates the average cost per unit of electricity over the life of the project. As of 2023, the LCOE of solar and wind energy in many countries is lower than that of coal or gas plants. For example, the average global LCOE for solar PV is now around \$0.05 per kWh, while coal is \$0.08 per kWh. This makes renewable energy not only cleaner but also cheaper in many cases.

3. Financing and Reducing Risk

Getting enough money to build renewable energy projects is still a challenge. Investors worry about risks such as changes in policy or market conditions. Governments and international organizations help reduce these risks. Power Purchase Agreements (PPAs) are one solution.

In a PPA, a buyer agrees to buy electricity from the renewable energy producer at a fixed price for a long time (usually 15–25 years). This provides income stability and makes it easier to get loans from banks. In many developing countries, blended finance is used. This means combining public and private money to fund projects. The government or a donor agency provides some of the money, which makes the project less risky and more attractive to private investors.

Economic Incentives for Clean Energy

Governments use different strategies to encourage people and companies to invest in renewable energy. These strategies reduce costs and risks, making clean energy more appealing.

1. Feed-in Tariffs (FiTs)

Feed-in Tariffs guarantee a fixed price for electricity generated from renewable sources. For example, in Germany's Energiewende program, producers of solar and wind energy were paid a fixed rate for every unit of electricity they supplied to the grid. This made it easier for individuals and businesses to invest in clean energy systems.

2. Tax Benefits and Subsidies

Tax credits and subsidies are powerful tools. In the United States, the Investment Tax Credit (ITC) allows renewable energy project developers to deduct a percentage of their investment costs from their taxes. Similar programs exist in India, China, and other countries. Governments also provide grants or low-interest loans to lower the upfront cost of renewable energy systems. For example, India's government supports rooftop solar systems through subsidies covering up to 40% of the cost.

3. Renewable Energy Standards

Some countries have laws that require a certain portion of energy to come from renewable sources. These are called Renewable Portfolio Standards (RPS). For example, California aims to get 60% of its electricity from renewables by 2030. These standards help create long-term demand for clean energy and give investors' confidence that their projects will have a market.

4. Net Metering

Net metering allows people with solar panels to send extra electricity to the grid and receive credit on their electricity bills. This makes solar power more affordable for households and small businesses. In countries like Australia and Italy, net metering programs have led to rapid growth in rooftop solar installations. It also helps reduce pressure on power plants during peak hours

Green Finance

Green finance means using money for projects that benefit the environment. It includes funding for renewable energy, energy-efficient buildings, low-carbon transportation, and more. Green finance is essential to reach climate targets and build a cleaner economy.

1. Green Bonds

Green bonds are loans where the money must be used for eco-friendly projects. For example, the Indian Railway Finance Corporation raised over \$500 million through green bonds to support electrification of railway lines. The global market for green bonds reached over \$500 billion in new issuances in 2022, showing growing investor interest in sustainable development.

2. ESG Investing

Environmental, Social, and Governance (ESG) investing means putting money into companies that follow responsible practices. Many pension funds and mutual funds now include ESG criteria in their decisions. For example, Norway's \$1.4 trillion sovereign wealth fund avoids investing in companies that cause serious environmental damage. Instead, it supports businesses involved in clean energy and sustainable practices.

3. Climate Funds

The Green Climate Fund (GCF) and the Climate Investment Funds (CIF) help developing countries build renewable energy systems. The GCF has funded over 200 projects in 129 countries, with a focus on solar, wind, and small hydro systems. These funds help reduce the gap between rich and poor countries in the fight against climate change.

4. Public-Private Partnerships

Public-Private Partnerships (PPPs) allow governments and businesses to work together. One example is the Rewa Ultra Mega Solar Park in India. It was developed through a partnership between the government and private companies and now supplies clean energy to the Delhi Metro and other consumers are useful because they combine public money with private sector efficiency.

Carbon Pricing

Carbon pricing puts a cost on carbon emissions. This encourages companies to reduce pollution and invest in clean technology.

1. Carbon Tax

A carbon tax is a fixed charge per ton of carbon dioxide emitted. For example, Sweden charges about \$130 per ton of CO₂. This has helped the country reduce emissions by over 25% since 1990, even while its economy has grown. The money from carbon taxes can be used for public transport, renewable energy, or returned to citizens as rebates.

2. Emissions Trading Systems (ETS)

In a trading system, the government sets a limit on total emissions. Companies get or buy permits. If they emit less, they can sell their extra permits to others. This creates a market for emissions reductions. The European Union's ETS is the largest in the world. It has helped reduce emissions in the power and industrial sectors by over 40% since 2005.

3. Worldwide Use and Benefits

More than 70 countries and regions use carbon pricing. These include Canada, South Korea, China, and South Africa. Carbon pricing sends a clear message: polluting costs money. It supports innovation and helps renewable energy compete with fossil fuels.

Challenges and Opportunities

Even though clean energy is growing fast, there are still barriers:

- High upfront costs for new projects.
- Unstable policies or unclear regulations.

- Poorer countries may lack access to green finance.
- Resistance to carbon pricing from some industries.

However, there are also many opportunities:

- Technological innovation is making clean energy cheaper.
- International cooperation can bring financing and support to poorer regions.
- Education and public awareness can create stronger support for climate policies.

One success story is Morocco's Noor Ouarzazate Solar Complex, one of the largest in the world. It was built with help from international finance and now powers over a million homes.

Conclusion

A clean and secure energy future is possible. Economic tools like green finance, tax incentives, and carbon pricing can help make renewable energy the best choice for investors and consumers. Governments, businesses, and citizens all have a role to play. With the right support, we can reduce pollution, protect the environment, and ensure that everyone has access to reliable, affordable energy. By working together and using smart economic policies, we can build a future that is both sustainable and prosperous.

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